The 12th Annual Southeast Ultrafast Conference SEUFC 09

January 15th -16th , 2009

hosted by

Coherent Inc.

and

Townes Laser Institute

College of Optics & Photonics

Department of Chemistry

at the

University of Central Florida,

Orlando FL

Welcome to the 12th annual meeting of the Southeast Ultrafast Conference sponsored by Coherent and University of Central Florida School of Optics, Department of Chemistry, and the Townes Laser Institute.

In addition to the sponsoring organizations at University of Central Florida we would also like to add thanks to the following departments and research groups for their sponsorship of students to be able to attend this year's conference.

Vanderbilt University, Department of Physics and Astronomy, Nashville, Tennessee
Norman Tolk Labs
Richard Haglund Group

Georgia Institute of Technology, Department of Physics
Rick Trebino Group

University of Georgia, Department of Physics and Astronomy, Athens, Georgia
Susan Ullrich Group

University of South Carolina, Department of Physics and Astronomy
Thomas Crawford Group
Mark Berg Group

University of Florida
Dave Reitze Group

Congratulations to the Coherent Student Travel Grant Award winners:

Nick Evans – University of Georgia
Jingbo Qi _ Vanderbilt University
William Potter – University of Georgia
Jinho Lee – University of Florida

Thursday: January 15, 2009
University of Central Florida – CREOL-Townes Laser Center – Orlando, Florida

[illegible]	Morning juices and pastries with Registration
[illegible]	**Welcome remarks:** **Scott Crane** - Coherent Inc. **John Mackay** - Coherent Inc. **Martin Richardson** - University of Central Florida, Director, Townes Laser Institute
[illegible]	Plenary Speaker: **STEVEN T. CUNDIFF** JILA, National Institute of Standards and Technology and University of Colorado Chief of the Quantum Physics Division Professor, Department of Physics and in Electrical and Computer Engineering Department Ph.D. in Applied Physics, 1992 - University of Michigan. *"Optical Two-Dimensional Fourier Transform Spectroscopy of Semiconductors"*
[illegible]	**Questions and discussion**
[illegible]	**Break**
[illegible]	**Norman Mannella** Assistant Professor - Condensed Matter Physics, University of Tennessee – Knoxville, Tn *"Soft x-ray spectroscopies studies of sub-picoseconds dynamics in complex electron systems"*
[illegible]	**Steven Kuebler** Assistant Professor of Chemistry and Optics Department of Chemistry and CREOL, The College of Optics & Photonics University of Central Florida, Orlando, FL *"Fabrication of Metallo-Dielectric Photonic Crystals using Multi-Photon Direct Laser Writing"*

Nick Evans
Graduate Student, **Susan Ullrich Lab,** Department of Physics and Astronomy University of Georgia, Athens

"The Photoprotective Properties of Adenine: Time-resolved Photoelectron Spectroscopy at different excitation wavelengths"

Lunch

Lunch talk:

George McNamara

Core Leader, Analytical Imaging Core
University of Miami, Miller School of Medicine, Miami, FL
"PubSpectra: Spectral imaging microscopy web sites and data"

John Mackay

Coherent Inc, Director, Scientific Research Systems
"New advances in short pulse technology"

Martin Richardson

Director, Townes Laser Institute, University Trustee Chair, Northrop Grumman Professor of X-Ray Photonics, Professor, Optics, Physics & ECE. College of Optics & Photonics University of Central Florida, Orlando FL
"High power fiber lasers and the future"

Samir Garzon

Research Assistant Professor, Department of Physics & Astronomy and USC Nanocenter, University of South Carolina Columbia, SC
"Coherent nanomagnet control via ultrashort spin torque pulses"

Break

Jingbo Qi

Graduate Student - Norman Tolk Group, Department of Physics and Astronomy, Vanderbilt University,
Nashville, TN
"Ultrafast photo-induced coherent spin dynamics in ferromagnetic semiconductor GaMnAs systems"

3:15	**Leonid B. Glebov** Senior Research Scientist, Photoinduced Processing Lab College of Optics & Photonics, University of Central Florida, Orlando FL *"Stretching and compression of short laser pulses by chirped volume Bragg gratings in PTR glass"*
4:15	**Lab Tours** – University of Central Florida Research Labs
5:00	**Poster Session and Wine and Cheese Reception** – CREOL Research Building
6:00	**Buffet Dinner – Market Place campus dinning facility**
8:00	**After dinner Speaker - Josh Colwell,** Assistant Professor of Physics, University of Central Florida *"Running Rings Around Saturn: Four Years of Discovery from the Cassini Mission"*

Friday: January 16, 2009
University of Central Florida –CREOL-Townes Laser Center – Orlando, Florida

8:30	Morning juices and pastries with Friday Registration
9:00	**Ken Knappenberger** Assistant Professor, Department of Chemistry, Florida State University, Tallahassee, FL *"Coherent Molecular and Nanoscale Dyanamics"*
9:30	**Ying Xu** Research Assistant Professor, Norman Tolk Group, Department of Physics and Astronomy, Vanderbilt University, Nashville, TN *"Band structure studies of buried materials using coherent acoustic phonons"*
10:00	**Break**
10:15	**Kevin Belfield** Professor of Chemistry, Chairman of the Department of Chemistry University of Central Florida, Orlando, FL *"Two-Photon 3D Optical Data Storage"*

10:45 **Pam Bowlan**

Senior Graduate Student - Rick Trebino Group, School of Physics, Georgia Institute of Technology, Atlanta, GA

"Measuring Everything that you ever wanted to know about an ultrashort pulse but thought was immeasurable"

11:15 **Steven McGill**

Assistant Scholar / Scientist Ultrafast Optics Facility Coordinator Condensed Matter Science, DC Field CMS, National High Magnetic Field Laboratory, Tallahassee, FL

"Ultrafast User Optics at the NHMFL in Tallahassee"

12:00 **Lunch**

1:00 **Ayman Abouraddy**

Assistant Professor Multi-material Optical Fiber Devices Group CREOL College of Optics, University of Central Florida, Orlando, FL

"Mid-infrared nonlinear optics in multi-material chalcogenide glass fibers: potential and challenges"

1:30 **Jinho Lee**

Graduate student under Prof. Dave H. Reitze Department of Physics and Astronomy, University of Florida, Gainesville, FL

Working at the NHMFL

"Ultrafast Absorption and Emission Dynamics of Dense Quantized Magneto-plasmas in High Magnetic Fields"

2:00 **Break**

2:15 **Richard Haglund**

Professor of Physics, Director of Graduate Studies Department of Physics and Astronomy, Vanderbilt University Nashville, TN

"Thermal vs electronic initiation of the semiconductor-to-metal transition in nanostructured vanadium dioxide"

2:45 Round Table Discussion and Conference Wrap-Up

Abstracts:

PLENARY SPEAKER:

Optical Two-Dimensional Fourier Transform Spectroscopy of Semiconductors

Mukamel Feynman diagrams Opt. Exp. 13 7432 (2006)

Steven T. Cundiff
JILA, National Institute of Standards and Technology and University of Colorado

The concept of multidimensional spectroscopy originated in NMR where it enabled the determination of molecular structure. The key concept is to correlate what happens during multiple time periods by taking a multidimensional Fourier transform. The presence of a correlation, which is manifest as an off-diagonal peak in the resulting multidimensional spectrum, indicates that the corresponding resonances are coupled. Migrating multidimensional Fourier transform spectroscopy to the infrared and visible regimes is difficult because of the need to obtain full phase information about the emitted signal and for the phase difference between the excitation pulses to be stable and precisely incremented. I will give an introduction to optical two-dimensional Fourier transform spectroscopy and then present our use of it to study many-body effects in semiconductors. Our results show that many-body effects dominate the light-matter interaction for excitons in semiconductors and provide a rigorous and quantitative test of the theory. We can isolate excitonic molecules, known as biexcitons. The techniques also allows non-radiative coherences, such as Raman or two-quantum coherences, to be isolated and measured.

Soft x-ray spectroscopies studies of sub-picoseconds dynamics in complex electron systems

quasiparticles in metallic state Nature Paper

Norman Mannella
University of Tennessee - Knoxville

Tokura Photoinduced Phase Transition

ABSTRACT

In the past few decades, revolutionary improvements in scientific instrumentation have been paralleled by impressive advances in materials synthesis, resulting in the discovery of an ever-increasing number of complex electron systems exhibiting exotic electronic and magnetic properties, with the most prominent example being the cuprate high temperature superconductors (HTSC) and the colossal magnetoresistive (CMR) manganites. A unifying characteristic of these complex electron systems is the capability of exhibiting spectacular and unexpected phenomena arising from the interactions between the electrons or other degrees of freedom (such as the lattice or spin). The strength of the interactions is so strong that a proper description of these materials can no longer be effectively reduced to a one-body problem, thus forcing the scientific

community to go beyond the usual approximation schemes based on single particle approximations. While ultimately promising revolutionary technological applications, complex electron systems thus represent several challenges for our fundamental understanding of condensed matter physics.

It is indeed this strong coupling between several degrees of freedom that is at the heart of both the novel properties of these materials and their technological applications. In this talk, by discussing the investigations of two prototypical colossal magnetoresistive manganites such as $La_{0.7}Sr_{0.3}MnO_3$ and $La_{1.2}Sr_{1.8}Mn_2O_7$ [1,2] and the newly discovered FeAs superconductors [3], I will provide a few examples illustrating how soft x-ray spectroscopies are capable of providing insightful information about the coupling of different degrees of freedom in complex electron systems. I will then discuss how the possibilities of performing soft x-ray spectroscopies with sub-picoseconds time resolution could constitute a new promising possibility of disentangling the coupling of different degrees of freedom based on the dynamical response of the excited electron states.

[1] N. Mannella et al., Phys. Rev. Lett. 92, 166401 (2004); N. Mannella et al., Phys. Rev. B 71, 125117 (2005).
[2] N. Mannella et al., Nature 438, 474 (2005)
[3] F. Bondino et al., Phys. Rev. Lett. 101, 267001 (2008)

Fabrication of Metallo-Dielectric Photonic Crystals using Multi-Photon Direct Laser Writing

Stephen M. Kuebler
[a]*CREOL, The College of Optics and Photonics and* [b]*Department of Chemistry*
University of Central Florida Orlando, FL, USA 32816

**kuebler@mail.ucf.edu; Tele: +1 407-823-3720; Fax: +1 407-823-2252;*
http://npm.creol.ucf.edu

Russel et al holey fibers
Science 2002

ABSTRACT

Interest in three-dimensional (3D) metal photonic crystals (MPCs) and metamaterials has grown considerably given their potential applications in optics and photonics. Yet, experimental studies of such materials remain few because of the difficulties associated with fabricating 3D micron- and sub-micron-scale metallic structures. We have developed a route to MPCs based on conformal metallization of micron-scale 3D polymeric lattices created by multi-photon direct laser writing. The resulting composite metallo-dielectric structures exhibit broad plasmonic stop bands for which the short-wavelength edge is set by the periodicity of the lattice. These optical properties are consistent with that expected for all-metal photonic crystals. These results suggest that the approach can be used to fabricate 3D MPCs of many symmetries and basis sets and opens a path for integrating such structures with other micron-scale optical elements.

The Photoprotective Properties of Adenine: Time-resolved Photoelectron Spectroscopy at different excitation wavelengths

Nick Evans

Graduate Student, Susan Ullrich Lab
Department of Physics and Astronomy University of Georgia, Athens

ABSTRACT

The UV photostability of biomolecules is determined by their excited state electronic relaxation mechanisms. To be effective, these mechanisms must operate on ultrafast timescales in order to dominate over competing photochemical processes that potentially lead to destruction of the biomolecule. Femtosecond time-resolved photoelectron spectroscopy (TRPES) provides unique capabilities for studying photoinduced processes in small polyatomic molecules. Changes in the PES, observed as the delay between the pump and probe pulses is scanned, can be associated with electronic configurational changes during the relaxation process. Analysis based on ionization correlations allows us to extract the electronic character of the excited states in addition to their lifetimes. TRPES has successfully been applied to the study of small biomolecular building blocks. In this talk I will present our recent work on Adenine photophysics and discuss challenges associated with molecular beam generation of larger biomolecular subunits such as Adenosine.

Coherent Nanomagnet Control via ultrashort spin torque pulses

Samir Garzon

Research Assistant Professor, Department of Physics & Astronomy and USC Nanocenter, University of South Carolina Columbia, SC

ABSTRACT

Spin Transfer Torque (STT), by which the magnetic moment orientation of a nano-scale magnet can be manipulated with an electric current instead of a magnetic field, has recently received much attention due to its possible use in the development of a new kind of Random Access Memory (RAM): the nonvolatile STT-RAM. Strategies to efficiently manipulate the magnetic moment of such "nanomagnets" attempt to maximize the effect of the spin torque by applying current waveforms precisely timed with the underlying nanomagnet motion. The characteristic timescale for free nanomagnet precession is ~300 ps and thus spin torque pulse durations of tens of picoseconds or less are required to achieve good control over the magnetic moment. We have used pairs of optically generated current pulses as narrow as 30ps to apply a spin torque at precise

moments along the otherwise free-precession orbit, allowing a direct mapping of the regions where the spin torque has the maximum effect on magnetic moment reversal. Here we will review the results obtained so far with our ultrashort current pulse technique, including 100% probability of magnetic moment reversal with a single 30 ps current pulse and coherent nanomagnet dynamics for over 1 ns even at room temperature. We will compare our results with macrospin simulations, which show that single or multiple ultrashort pulses can more efficiently switch a nanomagnet than a longer pulse with the same total energy. Finally, we will present partial results of our latest measurements, where we have complemented our ultrashort pulse setup with either a 5 ns current step or a dc current of small amplitude as a way to control the effective damping.

Ultrafast Photoinduced Coherent Spin Dynamics in Ferromagnetic $Ga_{1-x}Mn_xAs/GaAs$ Structure

Jingbo Qi
Graduate Student - Norman Tolk Group
Department of Physics and Astronomy, Vanderbilt University, Nashville, TN

ABSTRACT

Ultrafast pump-probe magneto-optical spectroscopy is used to study coherent spin dynamics in the ferromagnetic semiconductor $Ga_{1-x}Mn_xAs$ systems. Above GaAs bandgap Eg, the temporal Kerr signal is found to be strongly dependent on pump photon polarization. This polarization dependence is attributed to spins of electrons photoexcited to the conduction band, and disappears for $E_{ph} < E_g$. Below the Curie temperature T_C of the $Ga_{1-x}Mn_xAs$ samples, the temporal Kerr rotation acquires an additional oscillatory component, attributed to the precession of the ferromagnetically-coupled Mn spins. This precession is observed for excitation above and below E_g, regardless of the pump polarization states. The detailed characteristics of this ferromagnetic precession are discussed in terms of the Landau-Lifshitz-Gilbert (LLG) model.

Coherent Molecular and Nanoscale Dynamics

Ken Knappenberger Assistant Professor
Department of Chemistry and Biochemistry, Florida State University, Tallahassee, FL

ABSTRACT

The implementation of ultrafast laser-based measurements to probe events occurring over a large range of dynamic timescales will be described. First, the analysis of electronic and vibrational wavepackets formed in polyatomic molecules will be used to identify the influence of specific excited states on the outcome of photoinduced processes. Also, studies of single semiconducting nanoparticles will be presented. The results show that probability distribution and correlation analysis can be used to categorize the excitation-energy dependence that alters the fluorescence blinking statistics associated from single nanoparticles.

Band structure studies of buried materials using coherent acoustic phonons

Ying Xu, Research Assistant Professor,
Department of Physics and Astronomy, Vanderbilt University Nashville, TN

Time-resolved, wavelength dependent, pump probe studies using photo-generated traveling coherent acoustic phonon waves could provide layer-by-layer information about the electronic structure of materials over a wide depth range. At the anomaly in the electronic structure, such as the semiconductor band gap, a strong variation in the measured probe light intensity is observed, as the small perturbation arising from the propagating CAP wave modifies the electronic structure of the material. Semiconducting heterostructures interfaces and defect distributions have been investigated and successfully characterized using the CAP technique. Tow parameters are investigated in details, the phase and the amplitude. For heterostructures, we observe a distinctive phase discontinuity at the interfaces separating the layers when the probe wavelength is close to the bandgap. This phase discontinuity is a result of interplay between the traveling coherent acoustic phonon (CAP) wave, the electronic structure of the materials as modified by the CAP wave, and the subsequent photon probe interactions with the locally modified materials. For a radiation damaged lattice, we show that continuously varying amplitude changes in the phonon oscillations corresponds to the variation in the electronic structure in of He+-irradiated GaAs. We further demonstrate that absolute depth-dependent defect concentrations may be obtained through experimental calibration and are shown to agree well with simulation. This work confirms that coherent acoustic phonons are a novel and effective tool to study the detailed band edge structures of semiconducting and insulating materials. In addition, our results suggest that operating with probe energies near the band gap constitutes a valuable new approach for characterizing buried layers, with nanometer resolution.

Two-Photon 3D Optical Data Storage

Kevin D. Belfield, Professor
Department of Chemistry and CREOL: The College of Optics and Photonics
University of Central Florida
Orlando, FL 32816

ABSTRACT

The need for storage capacity has increased significantly over the past several decades. The quadratic dependence of two-photon absorption, 2PA, with respect to the intensity of incident light enables the photochemical processes that depend on this absorption to be confined to very small volumes. Hence, this nonlinear dependence leads to immense data storage capacity. We developed two 3D fluorescence-based readout systems. The first is rewritable, based on reversible transformations of a photochromic material with nondestructive FRET-based readout. The second is a WORM optical data storage system wherein protonation of a 2PA fluorene-based dye by a photoacid generator (PAG) is performed by either one- and two-photon excitation of

photosensitive polymer films. Specifically, we report the use of new photosensitive polymeric systems, comprised of novel 2PA absorbing dyes and PAGs in different polymer films (phosphorylated poly(VBC-*co*-MMA) and crosslinked thiolene polymers), for WORM optical data storage for one-photon 2D and near-IR two-photon 3D optical data storage.

PubSpectra: Spectral imaging microscopy web sites and data

George McNamara
Core Leader, Analytical Imaging Core
University of Miami, Miller School of Medicine, Miami, FL

ABSTRACT

The Internet is enabling greater access to spectral imaging publications, spectral graphs, and data than that was available a generation ago. The spectral imaging systems discussed in this issue of Cytometry work because reagent and hardware spectra are reproducible, reusable, and provide input to spectral unmixing and spectral components recognition algorithms. These spectra need to be readily available in order to determine what to purchase, how to use it, and what the output means. We refer to several commercially sponsored and academic spectral web sites and discuss our spectral graphing and data sites. Sites include fluorescent dye graph servers from Invitrogen/Molecular Probes, BD Biosciences, Zeiss/Bio-Rad Cell Sciences, and filter set servers from Chroma Technology and Omega Optical. Several of these sites include data download capabilities. Recently, two microscope manufacturers have published on their web sites transmission curves for select objective lenses-crucial data for anyone doing multiphoton excitation microscopy. Notable among the academic sites, PhotoChemCAD 2.0 has over 200 dyes and a downloadable database/graphing program, and the USC-A Chemistry UV-vis Database displays absorption spectra of many dyes and indicators used in clinical histology and pathology. Our Fluorescent Spectra graphing/calculator site presents dyes, filters, and illumination data from many of these and additional sources. PubSpectra is our free download site which uses Microsoft Excel files as standardized human/machine readable format with over 2,000 biomedical spectra. The principle that data is not subject to copyright provides a framework in which all scientific data should be made freely accessible.

Mid-infrared nonlinear optics in multi-material chalcogenide glass fibers: potential and challenges

Ayman F. Abouraddy
The College of Optics & Photonics, CREOL University of Central Florida

ABSTRACT

Chalcogenide glasses offer exciting potentials for nonlinear optics. For example, the nonlinear coefficients of several chalcogenide glasses have been found to be two to three orders-of-magnitude higher than that of silica glass, thus making chalcogenide fibers an attractive route to efficient nonlinear fiber optics. Moreover, in contrast to silica glass, chalcogenide glasses are transparent in the mid-infrared. Nevertheless, the field has not yet flourished as might have been expected. In this talk I review the potential for mid-infrared nonlinear optics in chalcogenide glass fibers and the hurdles that need to be overcome. I will also give an overview of my new group's research concerning the development of novel multi-material chalcogenide fiber structures.

Ultrafast Absorption and Emission Dynamics of Dense Quantized Magneto-plasmas in High Magnetic Fields

Jinho Lee
University of Florida – Gainesville, FL

ABSTRACT

The application of a strong magnetic field perpendicular to the plane of a semiconductor quantum well generates a series of Landau levels (LL) in which the zero-field step-like 2D density of states transform into highly degenerated δ-like 0D density of states ($N = eB/h$) as the magnetic field is increased. Intense ultrafast laser excitation results in a highly-quantized dense ($N_{e\text{-}h} \sim 10^{13}$ cm^{-2}) electron-hole plasma tightly confined in energy. The presence of many discrete Landau levels results in complicated relaxation dynamics which can occur through intra- or inter-level transitions. Earlier experiments have probed the ultrafast dynamics of magneto-excitons in LLs at much lower fields. We have recently reported on emission dynamics of dense magneto-plasmas in multi-quantum wells excited by ultrafast pulses in fields up to 30 T, where a transition from spontaneous emission to amplified spontaneous emission to superfluorescent emissions as the magnetic field and fluence are increased. Here, we report on complimentary investigations of the relaxation and emission dynamics of dense magneto-plasmas using ultrafast transient absorption (TA) and time resolved photoluminescence (TR-PL). At high magnetic fields, we observe a dramatic and qualitative change in the transient absorption dynamics with respect to zero field dynamics – all LLs exhibit an initial fast increase in transmission, however the transmission signal exhibits *an abrupt, non-exponential reduction* after the initial excitation. Similar dramatic changes are observed in time-resolved photoluminescence measurements. At high fields, the emission consists of multiple and rapid bursts of PL separated in time appear from each LL. We will discuss the physical origin of the signal in the context of intra-LL relaxation and inter-level recombination transitions.

Thermal *vs* electronic initiation of the semiconductor-to-metal transition in nanostructured vanadium dioxide

Richard Haglund
Professor of Physics, Director of Graduate Studies
Vanderbilt University, Nashville, TN

Research group: http://sitemason.vanderbilt.edu/physics/aopg/home
Personal Web page: http://sitemason.vanderbilt.edu/physics/haglund

ABSTRACT

For half a century, strongly correlated vanadium dioxide has elicited intense interest from experimentalists and theorists as they have attempted to understand the complex nature of the semiconductor-to-metal transition (SMT) in this material. In this talk, I will describe a series of experiments in which we have sought to understand the characteristics of the SMT as it is revealed in nanostructured materials. Using techniques ranging from ultrafast THz spectroscopy to single-nanoparticle Raman microscopy, we are learning how to understand the size dependence of the SMT. Of particular interest are the differences that are now emerging between the behavior of nanostructured vanadium dioxide when the SMT is induced thermally rather than with nanosecond or femtosecond above-bandgap laser excitation.

STUDENT POSTERS:

Ultrashort Laser Pulse Interaction with Photo-Thermo-Refractive Glass

Authors: Leo Siiman, Dylan Moses, Julien Lumeau, Leonid B. Glebov
Presenting author: Dylan Moses, Ph.D. Student

College of Optics & Photonics: CREOL & FPCE, Univ. of Central Florida

Abstract

Photo-thermo-refractive (PTR) glass is a multi-component silicate glass with intrinsic absorption edge at 6 eV (205 nm). A classical method for the activation of its photosensitivity implies linear photoionization of cerium 3+ ions using a CW UV-laser. In this paper, we study the opportunity to photoionize PTR glass using ultrashort IR laser pulses. In this case we show that only glass matrix can be ionized. Using ultrashort laser pulses (100 fsec$< \tau <$ 1.5 psec) in the wavelength range from 0.8 μm to 1.5 μm, we show that for all studied wavelengths there is an interval of intensities where luminescence and photo-ionization occur without associated laser damage. Filaments are observed inside the glass bulk during irradiation as a result of balancing between Kerr self-focusing and defocusing by free electrons produced by strong-electric-field ionization. Keldysh theory is used to model the formation of filaments and values of about 10^{13} W/cm^2 for laser intensity and 10^{19} cm^{-3} for free-electron density are estimated. These values are in agreement with the experiment. This phenomenon is used to explain nonlinear photosensitivity in PTR glass.

****

Two and/or three photon absorption in germanium

Presenting author: Dongmin Seo
Vanderbilt University, Ph.D. Student
Department of Physics and Astronomy, Vanderbilt University

Abstract:

Wavelength and fluence dependent transmission through single crystal germanium [100] was studied in the mid-infrared ranging from 2.8 μm to 5.2 μm. The Vanderbilt Free-Electron Laser was used to produce trains of high-power picosecond laser pulses. Transmittance as a function of fluence at 2.8 μm and 4.4 μm were fitted by using two- and three-photon absorption, respectively. Data at 3.2, 3.6, and 4.0 μm, however, required consideration of simultaneous two- and three-photon absorptions in order to fit the experimental data. The two photon absorption coefficient at 2.8 μm (560 cm/GW) and three photon absorption coefficient at 4.4 μm (9.9 cm^3/GW^2) were acquired by data fitting.

Hydrophilic fluorene derivatives in two-photon fluorescence microscopy

Presenting author: Dao M. Nguyen
College of Optics & Photonics: CREOL & FPCE, Univ. of Central Florida

Abstract

Hydrophilic fluorene derivatives that contain polyethyleneglycol substituents have synthesized in good yield and characterized for their application as two-photon absorbing fluorescent probes for biological imaging. The hydrophilicity of the new molecules increases with the number of ethylene oxide units in the molecule. Symmetrical and unsymmetrical fluorene derivatives based on donor-π-acceptor, acceptor-π-acceptor, and donor-π-donor structural types were characterized by UV-vis absorption, fluorescence emission, and were found to exhibit high fluorescence quantum yields and high two-photon absorption (2PA) cross sections, making them quite suitable for probes in two-photon fluorescence microscopy (2PFM) imaging.

****

Measuring depth-dependent defect concentrations using coherent acoustic phonon waves

Presenting author: Heungman Park, Vanderbilt University, Ph.D. Student
Department of Physics and Astronomy, Vanderbilt University

Abstract

Coherent acoustical phonon waves have been utilized in the past to non-invasively and non-destructively measure optomechanical properties and thin film thickness. The process takes advantage of an interferometric phenomenon arising between intense, ultrafast optical pulses. Here we demonstrate that this technique may used to (a) measure electronic structure variations, and (b) obtain quantitative defect profiles in semiconductors as a function of depth. Using such phonon waves it is possible to characterize damage profiles a large dynamic range with depth limitations far surpassing conventional techniques.

****

Second harmonic generation at Si/SiO2 interfaces as a function of doping using femtosecond laser pulses.

Presenting author:: Heungman Park, Graduate student
Department of Physics and Astronomy, Vanderbilt University

Abstract

A femtosecond pulsed laser system was used to produce second harmonic generation (SHG) arising from Si/SiO2 interfaces. Due to the inversion symmetry, bulk SHG vanishes in silicon. Therefore, interface second-order susceptibility is the dominant source of SHG from the Si/SiO2 system. A highly focused laser beam induces a three-photon absorption process facilitating electron injection from the silicon valence band to the SiO2 conduction band and then finally to be trapped by ambient oxygen molecules on the surface of the oxide. The trapped electrons along

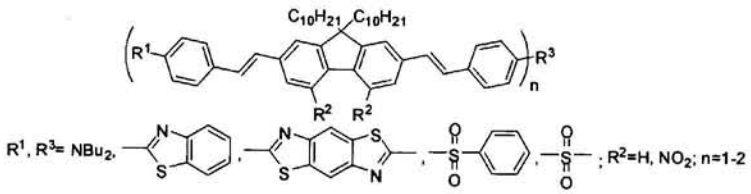
with holes left behind in the silicon create a slowly varying DC electric field across the Si/SiO2 interface. The observed SHG is a measure of the DC electric field at the interface. We observed an initial decreased in the SHG only with highly doped (boron) silicon wafers. The measured decrease in the SHG is attributed to boron induced electron traps, which create a DC electric field opposite to the photo-induced electron DC field.

****

Synthesis of Donor-Acceptor-Donor Two-Photon Absorbing Fluorene Derivatives

Authors: Sheng Yao,[a] Kevin D. Belfield,*[a,b] Jie Fu,[b] Eric W. Van Stryland,[b] and David J. Hagan[b]
Presenting Author: Sheng Yao
[a]Department of Chemistry & [b]College of Optics & Photonics: CREOL & FPCE, University of Central Florida, Orlando, FL 32816

Abstract



Both the magnitude and the wavelength of the two-photon absorption (2PA) need to be taken into account for developing materials for 2PA applications because the most efficient output wavelength of the Ti:sapphire laser source ranges from around 740 nm to 850 nm. One approach explored to achieve large 2PA in this wavelength range involved the synthesis of a series of donor-acceptor-donor (D-A-D) type fluorene derivatives with the general structure shown above. The linear and nonlinear optical properties, including UV-vis absorption spectra, fluorescence spectra, fluorescence anisotropy spectra and two-photon fluorescence excitation spectra, of these D-A-D compounds was determined and compared with their donor-acceptor counterparts. Large 2PA cross sections (>3000 GM) were achieved at ca. 800 nm. Further structure-property relationships of these chromophores will be discussed.

****

Formation of New Sulfonium Photoacid Generators by Microwave-assisted Reaction of Diphenyl Sulfides with Diphenyliodonium Salts

Authors: Ciceron O. Yanez,[a] Carolina D. Andrade,[a] Kevin D. Belfield*[a,b]
Presenting Author: Ciceron O. Yanez
[a]Department of Chemistry and [b]CREOL, [b]The College of Optics and Photonics, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816

We report a facile synthesis of a series of novel conjugated photoacid generators, PAGs, for potential use as two-photon absorbing (2PA) photoinitiators in negative resists for 3-D microfabrication or in optical data storage. Furthermore, we evaluated the convenience of forming these sulfonium salts by microwave-assisted reaction of diphenylsulfides in the presence diphenyliodonium salts. The effectiveness of this method was evaluated when performed on less conjugated sulfides that may be more relevant in UV or deep UV lithographic applications. Fluorescence and photoacid generation quantum yields were determined for the new PAGs

****

Synthesis and Characterization of Novel Fluorene-based Two-photon Absorbing Molecules

Authors: Carolina D. Andrade(1), Ciceron O. Yanez(1), and Kevin D. Belfield*(1),(2)
Presenting Author: Carolina Andrade, Graduate Research & Teaching Assistant
cdandrad@mail.ucf.edu

(1) Department of Chemistry, University of Central Florida, P.O. Box 162366, 4000 Central Florida Boulevard, Orlando, FL 32816
(2) CREOL, The College of Optics and Photonics, University of Central Florida, Orlando, FL 32816

Abstract

We describe the progress towards the synthesis and structural characterization of new fluorescent donor–acceptor and acceptor-acceptor molecules with high two-photon absorption (2PA), based on the fluorenyl ring system. In this approach, we have incorporated functionalities such as alkynes and thiophene rings through efficient Pd-catalyzed Sonogashira and Stille coupling reactions, in order to increase the length of the conjugation in our systems, as well as to evaluate the effect of these functionalities on their 2PA cross section values. Absorption and emission characterization of these new compounds was performed; several of the chromophores exhibit large Stokes shifts and possess high fluorescence quantum yields. The novel compounds may potentially be used in 3D-optical data storage systems, 2PA microscopy imaging, optical limiting materials, and photodynamic therapy.

****

Two-photon absorbing fluorene-based fluorescent probes for specific labeling of biomolecules

Authors: Alma R. Morales,1 Katherine J. Schafer-Hales,2 Kevin D. Belfield,*1 1Department of
Presenting Author: Alma R. Morales
Chemistry and CREOL, The College of Optics and Photonics, University of Central Florida, P.O. Box 162366, Orlando, FL 32816-2366, and 2Department of Hematology and Oncology, Winship Cancer Institute, Emory University, Atlanta, Georgia

Abstract

Closely involved in the progression of nonlinear bioimaging is the development of optical probes for investigating biological function and activity. Introduction of new fluorescent compounds possessing enhanced nonlinearities are essential for advancing the utility of two-photon absorption (2PA) processes in the biological sciences. We augment probe design by integrating high optical nonlinearities, increased hydrophilicity, and coupling with reactive functional groups for specific targeting of biomolecules, assuring a better impact on two-photon fluorescence microscopy (2PFM) imaging. Specificity is accomplished by incubating cells with fluorophore-labeled peptides or antibodies, facilitating the labeling of particular cellular structures. To address the demand for better performing probes, we prepared fluorophores tailored for multiphoton imaging, incorporating the succinimidyl functionality as a reactive linker for further coupling with a wide variety of biologically significant molecules. These fluorophores are based on the fluorene ring system, known to exhibit high fluorescence quantum yield and high photostability.

****

Simply Measuring the Electric Field of Very Long, Complex Pulses

Authors: Jacob Cohen, Pamela Bowlan, and Rick Trebino
Presenting Author: Jacob Cohen *(jcohen7@gatech.edu)*

Georgia Institute of Technology, School of Physics
837 State St, Atlanta, GA 30332 USA

Abstract:

We introduce a simple spectral-interferometric technique for measuring (in time) the intensity and phase of arbitrary complex pulses up to a 1-ns in length with less than 100-fs substructure. It uses a *low-resolution* spectrometer and multiple replicas of a reference pulse. ©2008 Optical Society of America

OCIS codes: (320.0320) Ultrafast optics; (320.7100) Ultrafast measurements

****

A Review of OPA for XFROG

Presenting Author: Peter M Vaughan

UltraFast Optics Lab Georgia Institute of Technology, School of Physics
837 State St, Atlanta, GA 30332 USA

Abstract

Optical Parametric Amplification (OPA) has one key feature which other instantaneous nonlinear optical processes lack; an exponential gain in the input signal field. Utilizing OPA for Frequency Resolved Optical Gating (OPA-XFROG) allows for the measurement of signal fields which otherwise would be below the nonlinear threshold. This process has been used to measure atto-Joule pulses, and can measure pulses with bandwidths of several tens of nanometers.

Few cycle, carrier-envelope phase stabilized Ti:Sapphire oscillator as an OPCPA front end

Presenting author: Michael Hemmer, Grad Student
College of Optics & Photonics: CREOL & FPCE, Univ. of Central Florida

Abstract

The presented Ti:Sapphire laser emits an ultrabroad spectrum ranging from 550 nm to 1200 nm produced directly from the oscillator. Dispersion compensation over such a wide spectral bandwidth is entirely managed by pairs of double-chirped mirrors. The spectral width allows for the generation of pulses having durations < 6fs and presenting only two optical cycles. The octave spanning spectrum also allows for direct carrier envelope phase (CEP) stabilization via a simple f-2f interferometer, leading to high stability and compactness. The average power is ~130 mW at 85 MHz repetition rate, leading to an energy per pulse of ~1.5 nJ. This oscillator is being used as the front end of the high peak power OPCPA laser system currently under development at the Townes Laser Institute.

****

Femtosecond LIBS: a better regime to analyze organic samples

Authors: Christopher BROWN, Matthieu BAUDELET, Candice BRIDGE, Matthew FISHER, Michael SIGMAN, Martin RICHARDSON
Townes Laser Institute, College of Optics & Photonics, UCF, Orlando, FL
And Paul Dagdigian Chemistry Department, Johns Hopkins University, Baltimore, MD

Abstract

It is important to understand the influence of the surrounding atmosphere on the LIBS analysis of organic materials, which are largely comprised of carbon, nitrogen, hydrogen and oxygen. Previous studies have shown that atmospheric nitrogen and oxygen can be ionized together with sample constituents and, as a consequence, skew the interpretation of the resulting spectra. This becomes extremely important when trying to detect explosives, due to the fact that most energetic materials contain higher concentrations of oxygen and nitrogen compared to the carbon and hydrogen in nonenergetic materials. This study makes a comparison of LIBS emission from the molecular species produced from the plasmas produced from organic thin film residues on a non-metallic substrate by both a 5 ns duration Nd:YAG laser (266 nm/1064 nm) and a 35 fs Ti:Sapphire laser (810 nm) in air and argon atmospheres. We show that LIBS signal induced by femtosecond pulses is not influenced by the atmosphere composition, giving a more important role to the molecular CN signal in the PCA analysis for energetic material detection, compared to the traditional nanosecond regime where the CN compounds can be created in the plasma by excitation of the air and heating of the plasma. The efficiency of the analysis is measured via Receiver Operating Characteristics (ROC) curves.

Filament-Induced Breakdown Spectroscopy on Organic Thin Films: Towards an Efficient Detection of Energetic Materials

Matthieu BAUDELET, Matthew WEIDMAN, Matthew FISHER, Candice BRIDGE, Christopher BROWN, Michael SIGMAN, Martin RICHARDSON,
Townes Laser Institute, College of Optics & Photonics, UCF, Orlando, FL, USA
And Paul Dagdigian Chemistry Department, Johns Hopkins University, Baltimore, MD, USA

Abstract

Filamentation of femtosecond pulses can provide a high energy-density source of light at long distance by creating a self-guided filament of light, with high intensity (5x1013 W/cm², 100 μmdiameter), which can be used to create a plasma at distance for LIBS analysis. To improve the remote detection of energetic thin films, primary studies at close ranges of detection are needed. Polymer and explosive-like thin films deposited on non-metallic substrates are irradiated by self-channeled light filaments. We focus on the characterization of the spectral signatures from energetic samples with the emphasis on transitions in atomic and ionized C, H, O, and N, as well as and molecular (C2 and CN) transitions. There is no atomic carbon emission, but CN molecular signals even when no nitrogen in the sample. Previous studies have shown the importance of the molecular band for organic samples detection. But, in this case, filamentation creates a ionized channel in the air immediately in front of the target, so reactive ionized and excited species are present in the atmosphere from the beginning of the plasma expansion. In addition, the very small proportion of atomic species ablated from the sample compared to the reservoir of atmospheric molecules in the surrounding atmosphere can possibly explain the lack of atomic emission. Those factors enhance the probability of the creation of CN radicals from native atomic carbon and nitrogen in the atmosphere, showing that molecular signal has to be used with care in explosive detection.